

# INFORMATION IS POWER

## Delivering Systems and Equipment Awareness With 3D Digital Sensing

Harbor Research was recently given the opportunity to examine prototypes of DeepStream Technology's Zircon Family of 3D circuits, a new embedded power monitoring platform that takes a refreshingly "pervasive" perspective on digital sensing technology. Deepstream's approach sidesteps the current marketplace noise and clutter surrounding wireless sensing by viewing electrical current as a ubiquitous "signature" for equipment and systems health and behavior. DeepStream has defined a new market meta-category and underscored the crucial importance of first-mover advantages in a networked world.

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**A**mid all the noise that seems to flow from the various discussions concerning the “universal” nature of wireless sensing, a new platform from DeepStream Technologies finally takes a “pervasive” approach to monitoring and control tools. The Zircon 3D Digital Sensing system enables product OEMs to add simple, unobtrusive remote monitoring to a broad range of ordinary commercial and household electrical devices and systems. It treats virtually all user concerns about equipment and systems—from comfort and convenience to safety and security—as a single problem that can be addressed by a single, scalable solution. In taking this perspective, DeepStream has defined a new market meta-category with vast potential: **Systems & Equipment Awareness.**

### **INFORMATION VALUE BECOMES POWER**

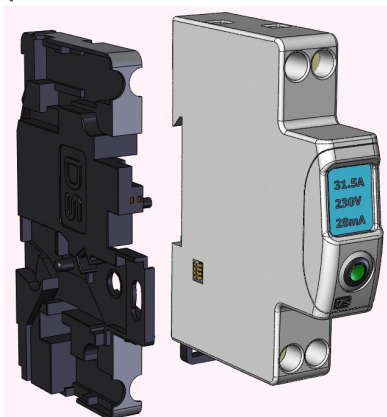
What if your electricity bill was managed automatically to give you the best possible rate... What if you could get early warning on possible unsafe conditions in your electrical system.... Be aware if you have a leak in your vacation home water heater .....and be able to switch it off through your cell phone..... Know from work if your refrigerator at home is still working after reports of power outages from a terrible storm ..... Feel confident that your kids are not playing on the computer after 11 pm..... Simulate a presence in your home by switching lights on and off in different patterns.....

All these ‘dreams’ share one common feature: electricity. Electricity is everywhere and certainly one of the most pervasive forces in our environment. Most objects we interact with in our environment utilize electricity to power them. What the

world is generally less aware of is the fact that electricity or electrical current is an almost universal “signature” that indicates various “states” about a system or piece of equipment. What do we mean by signature? Current tells us about whether something is on or off. But current also can tell us about the health or possible failure of equipment. We have now entered the age when everyday objects will communicate with, and control, other objects over networks—24/7/365, without human attention or intervention. Manufacturing and farming equipment, elevators and escalators, appliances and vehicles that know exactly when and why they will fail, and then alert you or your service organization before the failure occurs—or even, in some cases, fix themselves. Futurists have been describing such capabilities for decades. Yes, we’ve had a long history of promises about future technologies --cybernetics, robotics, adaptive systems -- but to date, almost nothing of real significance has come of it except on new and typically very expensive machines. What about all the rest of the machines out there? How can we monitor and manage the vast installed base of simple machines that impact all of our daily lives and, often, our livelihood?

### ENTER DEEPSTREAM TECHNOLOGIES

This white paper is about a fundamental break-through in sensing, monitoring and control technology. It was provoked by forthcoming products from DeepStream Technologies that Harbor Research recently had the opportunity to examine in prototype.



**DeepStream has combined advances in silicon, automotive and communications technologies in a unique fashion**

Zircon, DeepStream’s project code name for its power sensing and control platform, is a family of embedded modules each which includes sensors, accurate data



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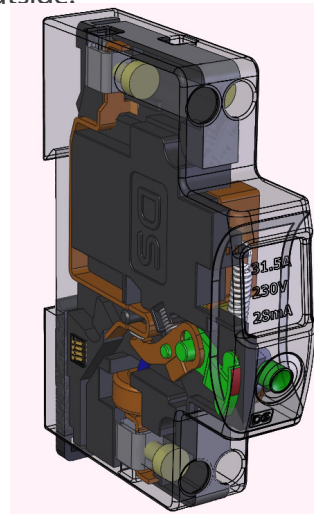
acquisition and signature analysis and communications blocks allowing for remote monitoring capabilities. These modules are particularly relevant for energy and safety monitoring in hostile environments or where available space is a critical factor.

DeepStream's Zircon modules are not an incremental new sensing or monitoring capability -- this is a significant step-function change in the way systems and equipment will be designed, constructed and managed in the future.

## 3D SHAPED CIRCUITS -- INTIMATE INTEGRATION VALUE

What if you had now the possibility of embedding the reading and usage of these signatures inside the device itself (appliance, circuit breaker, light bulb, electrical socket, battery, etc.) and based on the physical shape of the device which performs the functions. For the person installing it or using it.... it will still look and be connected/plugged/fitted like a circuit breaker, a light bulb or any component/device which you already have at home, in your office, or your hotel room.... with no additional bolt-on components bulging outside.

**DeepStream provides circuit level integration that can withstand harsh environments and fit into virtually any physical 3D space**



Inside, deeply embedded in a 3D substrate ....or as we like to think about it .... a "shaped circuit" ..... is an embedded monitoring circuit completely, physically molded in plastic in the shape of the space or object it is embedded into.

Conventional printed circuit board technology is limited in its ability to integrate with its "container" or "package" as it were. It requires mechanical fixing to the container to prevent damage to fragile circuit tracks or components from vibration or electrical shorts. The electronics need sufficient 'footprint' for the board and

mounts in both horizontal and vertical planes. It also needs a means of connection to both input (sensors) and output (load) circuits, connectors, etc. -- which are nearly always more expensive than the board itself. And in some cases, like the arc chamber of a circuit breaker, conventional electronic circuit board materials would not survive such an environment – plasma heat, high over-currents, voltages, etc.. In sum, electrical systems have not been friendly environments for integrating electronics and communications and therefore have not benefited as rapidly or significantly from these capabilities as other applications.

By incorporating technologies from the silicon, automotive and communication industries in a unique way, DeepStream has been able to overcome these limitations to provide circuit level integration in a module that can withstand extremely harsh environments, provide free mounts and connections, fitting into virtually ANY physical space that is available without major redesign.

## BACK TO THE FUTURE

Now that short-range wireless personal area networks (PANs) and local area networks (LANs) are common, “smart” products and systems are once again a hot topic. However, the distance between the promise of these communications technologies and their real-world “applied” value has not reduced as fast as everyone thought it might.

Today’s discussions of next generation wireless systems focus almost exclusively on communications -- the “pipe.” In other words, on things that look good in marketing campaigns and venture capital pitches. There are many popular visions about wireless monitoring and wireless control. Such as it is, short range wireless is a fantastic new advance -- no question. But, focusing on the communication element alone as first-order business amounts to grabbing the wrong end of the technology stick. Wireless alone steals the limelight and potentially eclipses the real revolution -- utilizing new technologies and processes to more tightly integrate sensing capabilities deep into existing products and systems with little or no design and cost impact.

Present day analog sensors and sensing systems such as Hall Effect transducers and current transformers for electrical voltage are well established but offer limited functionality -- really only offering users and OEMs raw analog data. In contrast, DeepStream’s digital sensors not only measure real-world signals but convert this



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raw sensor data to useful information about the application -- this creates new value in systems design and usage.

## DeepStream Technology : Measurements, Calculations & Functions

- *Current & voltage measurement*
- *Calculation of power - kWhr, VAR*
- *Calculation of power factor, harmonics*
- *Data logging & event capture*
- *Real-time signature analysis*
- *Networked communications -- wired & wireless*
- *Detection of complex circuit conditions*
- *Local & remote warning of faults*
- *Out of balance load sensing*
- *Sub-billing & usage recording*
- *Upgrade systems 'in-situ'*
- *Set parameters such as sensitivity*

The modules can be employed in autonomous devices where the digital sensor not only informs users, support personnel and systems but can also allow for actions to be initiated "locally" to the device to protect and control the application. This is a quantum leap forward in machine and systems design. These advances leverage the promise of highly distributed control -- "smart" de-centralized systems that are truly adaptive based on local digital processing capabilities.

### SEEING FAILURE BEFORE IT OCCURS

Most machine maintenance today is either purely reactive or blindly proactive. In the reactive case, equipment is fixed or replaced after it fails. With proactive maintenance, a certain level of performance degradation is assumed with no input from the machinery itself, and it is then serviced on a routine schedule whether service is actually needed or not. Both scenarios are wasteful.

Machines usually go through a measurable process of degradation before they fail. That degradation is largely invisible to human users, even though a great deal of technology has been developed that could make such information visible. Modern technology has driven the development of sophisticated sensors and computerized systems capable of delivering data about a machine's status and performance, but few machines today are monitored and even fewer are remotely managed.

The problem, for the most part, is that these systems are largely "bolt-on" in nature and often too expensive for all but the most mission critical equipment. We have technology, but we have not driven the technology intimately into the design of the equipment and we have not done so in an affordable manner. The ability to

intimately monitor in real-time the performance of most common machines is impeded by the slow pace of adoption of more advanced sensing technology.

Why is this? Either machine designers are unaware of the advances or more commonly the machine builder will not bother to initiate expensive re-design of equipment until a revolution or competitive circumstance dictates the update. Today, we would certainly say the emergence of India and China as formidable engineering cultures is enough to motivate some. But with the introduction of innovations like DeepStream's 3D circuits there really is no excuse not to upgrade the capabilities of existing equipment or drive revolutionary new concepts and designs.

#### WHAT DOES THE AWARE SYSTEM LOOK LIKE?

At the end of the day, awareness implies a total paradigm-shift. It's a shift from knowing "what happened" to knowing "what is happening"—all the time—and then automatically controlling systems with that knowledge. Here are some System and Equipment Awareness application scenarios:

**Energy management** -- combining the pervasiveness of the internet with digital sensing modules will drive new capabilities for attaining clean reliable power. As concern grows around power quality, availability and uptime, DeepStream provides a unique unobtrusive means to provide customers with detailed load profiles and pricing information that will empower end users to take control of their energy use.

**Power distribution** -- digital circuit breakers that will enable the power distribution/switch gear manufacturers to transition from a mature product-focused orientation to a solutions and services-based business model with the ability to deliver on mission critical power requirements and do so in a recurring revenue scheme. Additional benefits will grow in the areas of sub-billing/metering, easier servicing of equipment and the ability to upgrade 'in-situ' & set sensitivity parameters. Ultimately, organizing load management without disrupting consumers life styles will be key to attaining important "green" goals in society.

**Medical implants** -- intelligent sensors integrated into disposable probes and connectors that doctors can remotely monitor in real-time, no matter where the patient is -- from emergency services, to operating theater, to home monitoring of the elderly.



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**Condition monitoring** -- integrated sensing, monitoring and control capabilities for a wide range of consumer appliances and commercial equipment (e.g. laundry equipment, photo booths, photocopiers, refrigerators, etc.) that add safety, diagnostic, and energy management features for little, if any, additional cost (e.g. out of balance load sensing for rotating equipment; in-service feature upgrades -- latent or new; built-in signature analysis capabilities that allow users and management to set policies for systems management without complex programming).

## Market Sectors & Applications DeepStream Technology Fits Well With

- **Switchgear** • RCD, GFI, AFCI, MCCB
- **Appliances** • Washer, Dryer, Fridge, Dish Washer, Oven
- **Batteries** • Cell level monitoring, failure prediction in UPS
- **Automotive** • Battery, lighting, windows, Under bonnet
- **Medical** • Cardiac, Glucose, Temperature, Ultra Sound
- **Lighting** • DALI Controls, wireless public lighting

Ultimately, system awareness comes from sensing and feeding the real-time inputs of billions of tiny “state machines” into systems that continually compare machine-state to sets of rules and then do something on that basis.

### SYSTEM AWARENESS SHOULD BE SIMPLE AND SEAMLESS

The significant feature of these applications is not really their gee-whiz factor but precisely the opposite: the great convenience and service offered by their near-invisibility.

Well-designed “System Aware” technology should:

- Be inexpensive, wireless, easy to install and intuitive to use.
- Integrate energy metering and related measurements;
- Add digital capabilities for improved accuracy and safety features thus converting “dumb” electro-mechanical products to “smart” solution platforms.
- Be modular and easy to integrate and extend throughout product families over time.

- Be extensible (new sensors work with the existing system, preserving buyer investment).
- Offer varying degrees of remote alarms and control where desired (such as activating a water shut-off in the event of a leak).
- Integration with a broad array of IT devices for alerts, management and support of systems (e.g. PDAs, IR, mobile phone, etc.).
- Deliver value transparently without requiring full user/owner attention.

In the long run, such “invisible” machine-to-machine applications will be much more important to business—and to the evolution of civilization—than dramatic and intrusive services that require human attention to deliver full value.

### **DELIVERING NEW VALUE AND PROTECTING PRODUCT OEM INVESTMENT**

DeepStream’s innovative technology allows systems and equipment developers to retrofit custom-designed digital 3D modules into existing products. The new technology displaces a wide range of electro-mechanical components which creates the space for the new module. This minimizes product disruption and provides new enhanced feature sets and communications capabilities. This technology is designed to be cost-neutral and in some cases more cost effective than the previous generation of “dumb” electro-mechanical components. Not only do these modules extend product life and increase return on investment but they also enable new service revenue streams.

Future machine to machine applications will depend upon manufacturers outfitting their products with intelligence and connectivity in order to drive growth with new value added services. More importantly, it allows product OEMs to develop a continuous relationship with the customer diminishing the threat of dis-intermediation. We like to call this trend “Smart Services” -- it is already happening as we write this and will increase exponentially during this decade. Many products of the future will actually be portals into next generation services -- product OEMs integrating capabilities such as DeepStream is enabling to offer elegant and unobtrusive -- sometimes even invisible -- portals into the new world of networked services.

### **EMBEDDING THE INTERNET INTO THE REAL WORLD - GETTING THEIR FIRST**

If this is such a good idea, why hasn’t it been done before? In short, making 3D shaped circuits that can survive harsh real world environments is extremely difficult



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-- many organizations have tried. DeepStream's 3D embedded modules literally physically incorporate digital sensing and the Internet into equipment and systems, making something like a "smart building" much easier to contemplate than ever before. The building itself is literally on the Internet and the Internet is in the fabric of the building. DeepStream provides a more universal alternative to the many existing techniques for connecting ordinary electro-mechanical devices to networks for monitoring and remote management - their technology enables sensing capabilities not available at low cost for installed machines. Other techniques that allow remote management all have something to recommend them; each is optimized for a special purpose but none with the ability to reduce or eliminate the costly and difficult process OEMs go through to add new capabilities to their products.

## ULTIMATE VALUE

Of all the new capabilities that DeepStream's technology enables signature analysis and pattern recognition to profile systems and machine behavior is potentially the most compelling. The value of this type of capability is probably best exemplified by Amazon.com and Google. Amazon's ability to recommend various books and publications to users based on profiling patterns and Google's indexing of web and related content to drive advertising revenue underscore the new economic value of smart systems. Amazon stopped being a "store" and started being an intelligent entity that, to some very real degree, understood who you were and what you cared about. Google quickly transcended being a search engine and reached for an understanding of what the population found interesting and designed targeted advertising as an entirely new business model. In DeepStream's case, this translates into system optimization, extraordinary new partner and customer intimacy via connectivity, and "enterprise automation."

## POWER IS INFORMATION

Visions of some fantastic future? Not anymore. Everyone agrees that information is power. To date, business has had the sketchiest of information about its own goings on—partial pictures, isolated snapshots, fleeting, blurry, outdated glimpses. With electrical current intimately sensed, businesses and consumers the world over will be able to turn power into valuable information.

## About Harbor Research, Inc.

Harbor Research Inc. has more than twenty years of experience providing strategic consulting and research services to high technology clients. Harbor's strategy and business development work is organized around emergent and disruptive growth opportunities. The firm is a thought leader on the convergence of intelligent device computing and global networking—the phenomenon we call “the Pervasive Internet” -- Harbor was the first firm of its kind to focus on this arena.

The emergence of the Pervasive Internet is unleashing an age of “living intelligence” and “smart services” enabled by networked devices. The challenges and opportunities presented by the Pervasive Internet are profound and go to the heart of how companies perceive the markets they are in, how they organize themselves and how they approach business opportunities. Harbor Research's extensive consulting and analysis experience provides clients an unparalleled perspective on the impact of the Pervasive Internet on strategy and business processes.

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